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Performance Measures for Simulation

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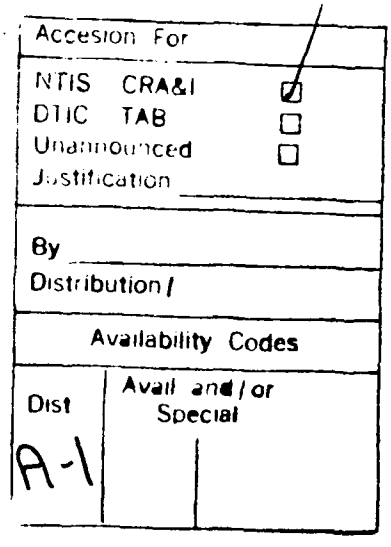

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The Close Combat Test Bed (CCTB) provides an environment where future armor combat systems can be simulated and evaluated. This research product lists and explains the baseline system performance measures developed from previous CCTB studies. The six baseline system performance categories are mission performance, information acquisition and communication, tactical assessment and planning, operational control of unit, unit positioning and navigation, and target acquisition and engagement. This catalog of performance measures will be updated every 2 years as more research is conducted.

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Performance Measures for Simulation

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FOREWORD

The Future Battlefield Conditions team of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Fort Knox Field Unit is responsible for conducting research to enhance soldier preparedness to meet the demands of future battlefields. The team does this by conducting research using the state-of-the-art soldier-in-the-loop simulation capabilities in the Close Combat Test Bed (CCTB) at Fort Knox.

This research was conducted under the task entitled "Technologies for Advanced Mounted Warfare Training." ARI's research in this area is supported by two Memoranda of Agreement. One is between ARI and the U.S. Army Armor Center and School on Research on Future Battlefield Conditions (12 April 1989). The second is between ARI and the Tank Automotive Command (TACOM) on the Combat Vehicle Command and Control System (CVCC) (22 March 1989).

Valid, reliable, and repeatable baseline performance measures are the key to evaluating soldier performance in future systems. Performance measures derived for the baseline system provide the standard for evaluating changes in soldier and unit performance due to the introduction of a new technology capability, or systems. Developing and refining baseline system performance measures is a resource intensive effort that could be improved if a catalog of up-to-date measures was available.

This document is primarily a catalog of baseline system performance measures developed in research efforts conducted in the CCTB. The baseline system measures have been categorized, referenced, and operationally defined to provide users a single reference source. Development of this product is part of a continuing effort to compile and maintain a database of baseline performance measures for simulation. It is intended that this product be updated every 2 years from ongoing CCTB research efforts. The information presented in this product is intended to assist researchers in developing more precise, reliable, and effective performance measures. Additionally, it is intended to provide lessons learned for ongoing efforts to develop standards for performance measurement in the Distributed Interactive Simulation (DIS) environment.

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PERFORMANCE MEASURES FOR SIMULATION

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PERFORMANCE MEASURES FOR SIMULATION

Introduction

The U.S. Army Research Institute's (ARI) Future Battlefield Conditions (FBC) team of the Fort Knox Field Unit conducts research using state-of-the-art technologies to determine training requirements for future battlefield systems. One focus of the FBC team is to simulate future Armor capabilities in the Close Combat Test Bed (CCTB) facility, formerly known as Simulation Networking-Developmental (SIMNET-D), and evaluate the impact of the proposed technology on individual and collective performance of Armor soldiers and units. This "soldier-in-the-loop" approach allows the FBC team and other investigators to examine the issues and problems that develop during the interaction of the soldiers with the new technology. The FBC team uses this approach to identify future training requirements and human performance issues that would affect the soldier's optimal use of that future technology and equipment.

To investigate how a future technology might affect the soldier's battlefield performance, a comparison must be made between the proposed system and an existing baseline system. Ideally, the two systems should be compared under identical test conditions to eliminate external factors from interfering with the planned comparisons. External factors should be controlled so that data can be collected reliably. The CCTB provides an excellent opportunity for investigators to conduct research and comparative evaluations of soldier and combat system performance in matched and controlled conditions. It also provides the capability to capture real-time performance data reliably and consistently. In addition, the CCTB provides the opportunity to rapidly configure and test future system equipment without the associated high cost of initial production and testing. These advantages have provided the FBC team with multiple opportunities to conduct and support research in soldier-machine performance with future Armor capabilities.

An important consideration in comparing soldier-machine performance between two systems is the construction of performance measures that yield data considered equivalent between the systems. Performance measures derived to measure soldier performance with new technology and equipment are useful for providing investigators with data for examining soldier-machine parameters, exploring new methods for performing battlefield tasks, and testing multiple iterations of the future technology. However, to adequately test the new technology or equipment, performance measures must be derived for the control case, the baseline system. Performance measures derived for the baseline system provide the comparative output data that allow successful comparisons to be made between future system

technology and current technology. Additionally, baseline system performance measures can be used in other avenues of research, such as evaluation and development of new tactical procedures or comparing the effects of different sized elements, i.e., the relative effects of three tanks versus four tanks in a platoon.

The purpose of this report is to provide a set of defined Armor baseline system performance measures used in FBC studies performed in the CCTB. These measures were culled from three research studies conducted from 1987 through 1990 (Du Bois & Smith, 1989; Du Bois & Smith, 1991; Leibrecht, Kerins, Ainslie, Sawyer, Childs, & Doherty, 1992). These particular measures are representative of the cumulative research efforts to date but should not be considered as a definitive list. Performance measures are continually developed and refined in ongoing research in the CCTB. It is intended that this list of baseline system measures serve as an aid to investigators conducting research, evaluations, tests, and pilot studies in facilities that utilize SIMNET technologies.

The remainder of this report covers a description of the CCTB facility resources, a brief review of associated research studies, descriptions of the baseline vehicle and crew configurations in the pertinent studies, descriptions of the CCTB data capturing methods and the levels of data collection, and the rationale for categorization and combination of the measures. In addition, this report includes sections on performance measure variability, how to use the tabled performance measures and operational definitions, and the actual performance measure table and definitions.

Background

While it is important that the reader understand the SIMNET equipment, capabilities, advantages, and limitations of the CCTB, it is not necessary to recount all the detailed information herein. Previous documentation (Miller & Chung, 1987; Garvey, Radgowski, & Heiden, 1988; BBN Systems and Technologies Corp., 1991) and ARI technical reports (Du Bois & Smith, 1989, 1991; Leibrecht et al, 1992) thoroughly describe the SIMNET resources and capabilities. Also, while it is necessary that the reader understand the pertinent research literature, it is not imperative that all the details of the special subsystem equipment, experiment, and findings be recapitulated. What is important is that the reader understand the relevant context a particular research effort has to the baseline system performance measures that were developed. In subsequent sections, summarized descriptions of the CCTB, its resources, and the research literature pertinent to this report are presented.

CCTB Overview

The CCTB at Fort Knox, Kentucky is a SIMNET facility containing low cost, distributed network simulators that simulate battalion and below combat operations and exercises. The simulation allows manned and semi-automated weapon systems, combat support elements, and combat service support elements to interact on a real world terrain. The CCTB's resources allow investigators to combine operational realism with soldier-in-the-loop simulation to allow experimentation and testing or evaluation of tactics, training, doctrine, and weapon systems (Garvey, Radgowski, & Heiden, 1988).

Manned Simulators

The central component of armor related research efforts in the CCTB is the M1 Abrams tank simulator. The following description of the characteristics, capabilities, and limitations represent the baseline simulator vehicle used in research to date. As explained by previous researchers (Du Bois & Smith, 1989,1991; Leibrecht et. al., 1992), the M1 simulator utilizes the concept of selective fidelity in its design. That is, the M1 simulator models the behavior of the real tank as much as possible and contains the minimum level of detail necessary for soldiers to perceive the system as realistic and useful. The simulator's visual and acoustic systems generate a realistic battlefield environment. Failures that would occur in a tank are also replicated in the simulation, i.e., a thrown track occurs when attempting to climb a 60 degree or higher grade.

However, some aspects of the tank are missing or curtailed. For example, the machine guns and gunner's auxiliary sight are not replicated. Also, there is no open hatch capability, a minimized visual fidelity in range (i.e., 3500 meters maximum) and in computer generated imagery, a restriction to daylight operations only, and a lack of vehicle identification plates. Some special features have been incorporated to offset the simulator's shortcomings. A grid azimuth indicator and turret reference display exist to offset the closed hatch operating mode. Special topographic paper maps are available to assist in terrain and feature identification. Tactical guidelines are available to moderate the visual range limitation.

Research, Data Collection, and Analysis Capabilities

The following descriptions of CCTB resources were summarized from detailed information presented in Du Bois and Smith (1989), BBN Systems and Technologies (1991), and Miller and Chung (1987). Not all the resources have been employed in an active roll in all the FBC experiments to date (i.e., Stealth Vehicle and video recording) but descriptions are included here so readers

understand all current capabilities that can be utilized for conducting research in the CCTB.

Semi-Automated Forces (SAFOR)

The SAFOR capability is a program that allows multiple automated, unmanned vehicles and aircraft to be simulated and controlled by trained controllers. Using a SAFOR workstation, a controller can create and place vehicles and aircraft anywhere on a SIMNET battlefield. Also, a controller can manipulate the behavior of the vehicles i.e., speed, direction, firing accuracy, engagement ranges, etc. SAFOR controllers can control opposing forces (OPFOR) or friendly forces (BLUEFOR). The SAFOR capability permits investigators to conduct studies using fewer personnel resources by letting a few controllers simulate many vehicles instead of having personnel man a simulator for each vehicle represented on the battlefield. In addition, the controllers can standardize testing and experiments because they can create, place, control and store the behavior of vehicles repeatedly and consistently across multiple iterations of the same mission, exercise, or phase in an experiment.

Plan View Display (PVD)

The PVD provides the capability to monitor and support assessments of simulated combat exercises. The PVD terminal displays a concurrent "birds-eye view" of the simulated battlefield during a real-time or recorded combat exercise. The display consists of color coded digital terrain which includes details like rivers, roads, and geographic features. Also, the PVD displays color coded icons representing manned and SAFOR combat vehicles, designations of friendly and enemy forces, all moving and firing events, direct fire locations, and artillery fire impacts. The PVD allows the operator to:

1. Flag or time-stamp exercise events.

2. Replay a combat exercise at different speeds.

3. Add and remove map features.

4. Zoom in or out of a specific area.

5. Get elevation and map coordinates for any point.

6. Acquire intervisibility readings between points and/or vehicles.

7. Choose vehicles and obtain their identity, location, speed, and ammunition, fuel, and repair status.

Management Command and Control System (MCC)

The MCC is an array of consoles (i.e., Battlemaster, Administration/Log, Fire Support, and Close Air Support) that permits monitoring and controlling combat, combat support, and combat service support events during SIMNET exercises. MCC capabilities include initializing vehicles at the beginning of exercises, placing simulators and targets, computing and broadcasting impact points for indirect fire, and controlling refueling and rearming activities.

Data Logger

The Data Logger is the central component of the data collection system that captures and records all SIMNET network data. It captures data from the simulators and the MCC via "specifically formatted Protocol Data Units (PDUs)" (BBN System and Technologies, 1991). Examples of PDUs or data packets include vehicle appearance, vehicle status change, vehicle collisions, direct and indirect fire events, projectile impact information, etc. All data packets can be time stamped and recorded on computer disk or tape for later retrieval and playback. This playback feature allows investigators to play back a recorded exercise in the original time sequence at a later time using VCR capabilities with the additional capability to select any view of the simulated battlefield.

Event Flagging

Exercise controllers have the capability to manually time-stamp any selected event via a flag PDU from the PVD. The flag PDU contains the type of event and the vehicle involved in an event. A flag PDU is entered into the SIMNET network and captured by Data Logger along with other PDUs. Event flags let investigators locate the exact occurrence of an event during data analysis. For example, the exact location of an M1 tank could be examined during a communication event like a SPOT report.

Video Recording

Miniature video cameras (Panasonic Model No. G0-CDI) mounted in the crew compartments allow investigators to unobtrusively monitor and record soldier actions at specific crew stations. The cameras are linked to VCRs which time stamp the footage in coordination with the Data Logger time.

Data Analysis Capabilities

As explained by Du Bois and Smith (1989), two software packages are available in the CCTB facility to reduce, manage, and analyze data captured by Data Logger. DataProbe is management and analysis software that accesses Data Logger and

provides the capability to label and define PDUs via a SIMNET Data Dictionary. DataProbe can use captured and defined data to produce descriptive statistics, color graphics and tables. The RS/1 product is an "interactive, programmable advanced statistics software package" (Du Bois & Smith, 1989. p. 9) that interfaces with DataProbe. It allows investigators to perform a wide variety of parametric, non-parametric, and descriptive analyses of the data. In addition, it provides the capability to record and store the data in formats and mediums for use by other computers and software packages. (DataProbe and RS/1 are registered trademarks of BBN Laboratories Incorporated and BBN Software Products Corporation, respectively.)

Also available in the facility are Analysis Library Routines that have been developed and compiled for calculating and summarizing various measures. Many performance measures have been produced by using these generalized routines developed by BBN personnel (BBN Systems and Technologies, 1991). The standard output routine provides statistical information based on shot-oriented data. An intervisibility routine calculates visibility between all combinations of paired vehicles at periodic intervals. Included in this routine is the exposure index that yields the cumulative time friendly vehicles are exposed to enemy vehicles. Another routine is the engagement timeline routine that calculates engagement times for all firing vehicles and intended targets. The GET XYs routine can extricate data for chosen vehicles at specified intervals. For example, vehicle velocity can be sampled every 30 seconds over an exercise and be statistically compiled to produce a mean or median velocity.

FBC Research

The following research is presented in chronological order and summarized according to the type of subsystem equipment evaluated. Each summary contains a brief overall description of the experimental evaluation, a general description of the baseline system performance measures developed for the experiment, and findings related to the performance measures. The experiments that will be discussed are: Position Navigation; Inter-Vehicular Information System; and Combat Vehicle Command and Control.

Position Navigation (POSNAV)

The POSNAV system is an automated navigational system designed to augment a tank commander's ability to navigate and maneuver in a complex battlefield environment. Capabilities of the POSNAV system include an analog spatial map display with own-vehicle icon, own-vehicle location and heading window, map features, zoom, and scroll functions, a route designation function, and a driver's steer-to indicator.

Du Bois and Smith (1989) conducted an empirical experiment to determine if armor crews and platoons using either of two automated POSNAV systems would significantly perform better than crews and platoons using conventional navigation techniques. The control group or baseline system group had an M1 simulator with the POSNAV system present but inactive. The POSNAV group had an active POSNAV system with either a grid matrix map display (POSNAV-G) or a terrain map display (POSNAV-T). Performance measures associated with navigational capability and tactical operations were developed to yield data for a comparative evaluation between the POSNAV and baseline systems. Performance assessment of individual crews was conducted during four tactical road marches whereas platoon performance was assessed over two offensive combat missions.

Results indicated POSNAV-equipped crews significantly completed road marches faster, used less fuel, travelled less distance, spent less time at halt, moved at faster velocities, reported own-tank locations quicker, reported own-tank locations and checkpoint arrivals more accurately, and required fewer crew navigation-related communications than crews without POSNAV. POSNAV-equipped platoons significantly outperformed platoons with baseline systems on several measures. POSNAV-equipped platoons: successfully completed combat missions more often; completed more mission segments; successfully completed more fragmentary orders; used less fuel; travelled less distance; spent less time at halt; maintained appropriate platoon dispersion more consistently; reported own-tank and target locations faster; and reported own-tank, target, and shell locations more accurately.

Inter-Vehicular Information System (IVIS)

The IVIS system is a computer-based command, control, and communication (C^3) subsystem designed to assist vehicle-level and above commanders in synchronizing and coordinating mission planning and execution. IVIS provides the tank commander (TC) with automated capabilities to "evaluate battlefield conditions, determine target locations, evaluate unit supply status, determine battlefield intervisibility, and rapidly prepare, transmit, and receive reports" (Du Bois & Smith, 1990, p. 17). POSNAV features are embedded in the IVIS system.

Du Bois and Smith (1991) conducted an empirical evaluation to assess if crews and platoons with IVIS-equipped vehicles perform better on C^3 and general mission tasks than crews and platoons without IVIS-equipped vehicles. Baseline system performance measurement was subdivided into constructs under either C^3 performance or general mission performance. Listed C^3 performance constructs included: react to a change of mission; bypass obstacles; issue calls for fire (CFF); report own location; report control measures; report enemy contact; report battlefield activity; report indirect fire activity; and select

and occupy a battle position. General mission performance constructs included execute mission, unit dispersion, acquire targets, and resource usage. These constructs contained groupings of performance measures similar to the POSNAV measures. Crew performance was assessed during an armor small unit C^3 exercise. Platoon performance was assessed during an offensive and defensive combat mission.

Crews and platoons with IVIS-equipped vehicles outperformed their baseline system counterparts on many performance measures. IVIS-equipped crews: completed their C^3 exercises in less time; sent more timely, complete, and accurate reports; and performed more change of mission, obstacle bypass, battle position, and CFF tasks successfully. IVIS-equipped platoons completed both combat missions more often, executed more mission segments, successfully completed more mission fragmentary orders (FRAGOs), and sent more accurate reports than platoons manning baseline vehicles.

Combat Vehicle Command and Control (CVCC)

The CVCC system uses the IVIS as a base and provides enhancements in the C^3 system that is designed to assist commanders at battalion-level and below in tactical operations. The system integrates features of the IVIS and POSNAV systems with a target and surveillance system and digitized communication features. Its features and capabilities include:

1. Commander's Independent Thermal Viewer (CITV) with a laser for acquiring and designating targets independent from the gunner's laser range finder.

2. Command and Control Display (CCD) with a full color tactical map and touchscreen control capability.

3. POSNAV system with waypoint designation capability for planning and executing routes.

4. Digital reporting capability with digital burst report transmission.

Leibrecht et al (1992) conducted a comparative evaluation to determine if companies with CVCC equipped vehicles performed significantly better on mission and tactical performance tasks versus companies with baseline vehicles. Company, platoon, and crew performance was assessed during phases (missions) of either an offensive or defensive scenario.

Performance measures were classified and sorted on the basis of functionality or task relatedness. The measures were divided into mission performance, tactical performance, and equipment usage. The category of mission performance included measures dealing with mission accomplishment and overall kills and losses.

Tactical performance measures were divided into five categories: information acquisition and communication, tactical assessment and planning, operational control of the unit, unit positioning and navigation, and target acquisition and engagement. CVCC equipment usage measures included CVCC equipment only, i.e., CCD and CITV usage.

Compared to baseline vehicle companies, CVCC-equipped companies on average: completed more missions; completed missions in less time; travelled less distance; consumed less fuel; transmitted more accurate FRAGOs and CONTACT reports; engaged, hit, and killed more targets during defense missions; engaged, hit, and killed more targets at greater distances during defense missions; and conducted unit displacement faster.

Performance Measurement and Data Collection

Baseline System Performance Measures

The baseline system performance measures, to date, have been developed to investigate the effects of future navigation, C^3, and integrated battlefield management systems on soldier-machine combat operational effectiveness. The range of measures have been restricted to ones that give comparative data for the systems under evaluation.

Not all measures developed for the comparative evaluations were used in this report. Some lacked discriminatory power or did not occur frequently enough to yield data. Other measures, like process measures, were only developed for comparing differences between alternate new systems, i.e., grid versus terrain display POSNAV systems. In addition, several system measures were combined to form higher level composites or to form combinations of measures that were scored according to an arbitrary criterion. While these measures were useful for the specific research they were derived to support, they are not cited here.

Data Capturing Methods

Various data capturing and collection methods were used in the three comparative evaluations. Although various methods were used, the data capturing process could be summarized as involving either automatic or manual methods. The automatic data collection method refers to programming the CCTB's automation equipment to sample and capture performance measure data during the collection process. The manual data collection method refers to the manual collection of data by humans via the automated equipment (i.e., flagging events into the Data Logger with the PVD), recording observations and data into a paper record (log), or using a combination of both during the collection process.

The two data collection methods are described in greater detail below.

Automatic

The automatic data capture method refers to the automatic data collection capability of the Data Logger and the Analysis Routine Library of standardized collection routines. Parameters for automatically sampling data at specified time intervals or at particular battlefield locations should be determined before an exercise is conducted or played back. The data can be automatically statistically summarized to yield descriptive statistical information (i.e., mean, median, counts, etc.) of interest. Manual intervention is not necessarily needed during the collection process. The performance measures collected via this method include, but are not limited to, engagement outcomes, range, dispersion, and system efficiency.

Manual

Manual methods refer to any data collection process that require a person to participate in the procedure during the collection process. Most of the reported measures including time, frequency, accuracy, and displacement, required human intervention. Manual data collection methods include staff members flagging events monitored on a PVD, making subjective judgements about observed performance and entering the data into data collection logs for later retrieval and summary, or a combination of event flagging via PVD and logging. As an event flagging example, a time flag was manually triggered at the end of a controllers prompt for a location report and then another flag was thrown at the end of the TC's report to measure a time interval for reporting location. An example of a log event would be a research assistant sitting in the loader's position estimating the percent of time the TC uses the vision blocks and marking the estimate in their log.

Levels of Measurement

Performance measure data was collected at varying unit levels throughout the three experimental evaluations. Three categories or levels are used to summarize the individual data points for the baseline system performance measures: crew, platoon, and company. Each level of measurement includes various individual data points that were used in the experiments to represent a unit level. The unit level was whatever finite point the unit was aggregated to in the specific performance measure. For example, the platoon level of measurement could be the mean performance of all four tanks on that particular measure. More precise definitions of crew, platoon, and company levels of measurement follow.

Crew

The crew level of measurement refers to the individual tank, crew, or crewmember(s) serving as an individual data point for performance measurement. Specifically, the collective performance of the crew manning the tank, the TC's performance, or the observed crewmember's interactions, represented most of the focus of performance measurement for crews in these comparative evaluations. Crew collective performance can be seen in data collected on a tank's performance, e.g., shooting and maneuvering performance. The TC's performance served as the focal point for crew level measurement in C^3 and tactical tasks, and use of resources (i.e., vision blocks, sights, or paper map). Crewmember navigation-related communications, were also representative of a crew level data point.

Platoon

The platoon level of measurement refers to: the platoon's performance as a whole entity; the performance of each tank, crew, TC, or crewmember interactions aggregated at the platoon level; the performance of either section within a platoon; or the performance of the platoon leader. The overall platoon performance can be seen in data collected on mission performance, dispersion, and navigation measures. The aggregate platoon level performance appears in data collected on TC resource usage, crewmembers' navigation-related communications, and the platoon aggregated efficiency data (i.e., mean fuel used, velocity, or distance travelled). Some platoon operational control performance measures contain dispersion data captured between and within platoon sections. Over a third of the platoon level measurement provided in this product is focused on the platoon leader's performance in either report timeliness, report accuracy, or planning a change of mission.

Company

For purposes of the company-level experiment, seven manned simulators were used. This configuration was referred to as a company slice. Each company slice consisted of one company commander (CC), one fully manned platoon (i.e., a platoon leader, platoon sergeant, and two wingmen), and two platoon leaders (PLs) for the remaining platoons. The remainder of the company assets (tanks) were represented by SAFOR vehicles.

The company level of measurement refers to: the total company's performance aggregated as a single data point; an aggregate measure of specified company vehicle's performance; an aggregate measure of all manned vehicles' performances; an aggregate measure of the CC's and PL's individual performances; the CC's performance; or the CC, any PL, or manned vehicle representing the entire company's performance. Company

performance, as a single data collection point, is reflected in overall mission performance measures, i.e., total enemy vehicles destroyed, time to execute missions, or mission completion times. Mission performance measures of manned or semi-automated vehicle losses represent specified aggregate company measurement. Loss to kill ratio for mission performance and efficiency measures were collected for all manned vehicles and aggregated for the company's representative performance. The CC and PL's reports and information requests were aggregated to reflect company communication performance. In some tactical performance measures the CC represents the entire company's processing. Singular performance or actions by either a CC, a PL, or any manned vehicle served to represent company performance in displacement, dispersion, or sector violation measures.

Performance Measure Classification

This section contains discussion concerning the development of the performance measure classifications or categories and performance measure classification issues. Also, performance measure categories are described.

Performance Measure Categorization

Leibrecht et. al. (1992) developed a method for classifying performance measures in the CVCC study that is useful for all the performance measures listed in this report. Leibrecht, et. al. classified their performance measures into general mission performance, resource usage, and tactical performance. Mission performance measures contained mission accomplishment measures and overall kills and losses. The resource usage classification dealt with only new system equipment usage (which is not relevant to this report of baseline measures). The tactical performance classification contained measures related to maneuver and command and control battlefield activities.

To further organize the tactical performance measures, Leibrecht et. al. used the Blueprint of the Battlefield doctrine to systematically classify tactical unit activities according to seven battlefield operating systems (BOS). The seven BOS are maneuver, fire support, air defense, command and control, intelligence, mobility and survivability, and combat service support (TRADOC Pam 11-9, 1990). The CVCC simulation scenarios only contained two BOS pertinent to their tactical measures: the maneuver BOS and command and control BOS. Based on the two BOS and their battlefield tasks, the authors distributed the tactical measures with similar activities among five categories: information acquisition and communication; tactical assessment and planning; operational control of the unit; unit positioning and navigation; and target acquisition and engagement.

Following this schema, presented by Leibrecht et. al., the baseline performance measures from the three studies have been classified into six categories for this report. Mission performance and the five categories of tactical performance (listed above) comprise the six categories. The mission performance category includes overall mission accomplishment measures and overall kills and losses. The information acquisition and communication category contains measures concerning the commander's acquisition of battlefield information and volume of radio reports. The tactical assessment and planning category encompasses measures associated with a unit's awareness of the tactical situation, evaluation of the battlefield information, and resulting tactical decisions and actions. The operational control of unit category contains measures referring to the commander's operational control over the execution of unit tactical activities related to formation and movement discipline. The unit positioning and navigation category is composed of measures reflecting maneuvering effectiveness and efficiency and crew navigation-related communications. The target acquisition and engagement category contains measures directly related to acquiring, hitting, or killing enemy vehicles.

Performance measures were not mutually exclusive in terms of fitting a single category. That is, some performance measures could be associated with another category than the one they were classified into. For example, the performance measure listed in the catalog under the Mission Performance category, "1.10 Percent enemy vehicles killed by manned vehicles," could probably be classified into the Target Acquisition and Engagement category as well. However, this measure was classified as a mission performance measure because it appeared to logically relate to overall mission performance by the manned company vehicles rather than specific target engagements. Thus, performance measures were sorted into categories where they had the strongest association.

Mission-Related Performance Measure Issues

Some issues had to be resolved in order to collapse mission performance measures across the various experiments. These issues to be resolved included: expanding the concept and definition of mission; lowering the collective level at which missions are considered to be performed; and defining experiment-specific nomenclature related to subtle differences between closely related mission performance measures.

The concept of mission was expanded to include exercise and phase which occur in the IVIS and CVCC experiments, respectively. According to ARTEP 71-2-MTP (1988), "a mission is a primary task assigned to a unit", i.e., seize an objective. A mission requires a unit to perform several related sub-tasks or

activities during its execution. In the three studies, a mission, an exercise, and a phase were essentially the same in that they were organized around a primary offensive or defensive task and included a core of maneuver, gunnery, and command, control, and communication activities or sub-tasks.

Usually, missions are assigned to units that are platoon level or above. Because the crews in the IVIS experiment were given the same mission task requirements for their exercise as the platoon, the crew level, for purposes of this summary, is included with the other units for consolidating this performance measure as one category. However, crews in the POSNAV experiment only performed tactical road marches, a task that would be performed in the normal course of a mission. Thus, road march is included separately as a performance measure in several categories.

In addition, there is some experiment-specific nomenclature that could pose some difficulties in the understanding of similar performance measures, i.e., IVIS mission events (Du Bois & Smith, 1989) versus POSNAV mission segments (Du Bois & Smith, 1991). It is important the reader have a clear understanding of the meaning of mission segment or event before proceeding to the table and definitions.

A mission segment or event is an interval of distance (and time) occurring between specific areas or locations described on a map overlay for a road march route, mission exercise, or planned mission. Segments are planned as sequential intervals over the duration of the mission or march with specific starting and ending points. Segments do not overlap but can share the same point, i.e., as an ending point for the previous segment and a starting point for the next. During segments, planned battlefield stimuli are presented to elicit or initiate doctrinally-based responses (individual and collective task execution) from the tested unit(s). Examples of battlefield stimuli are target engagements, indirect fire attacks, control measure crossings and arrivals, higher command orders or requests, etc.

Performance Measure Descriptions

The following six categories are listed and described in the order they appear in the catalog. A total of seventy two measures are included in the six categories.

Mission Performance

This category includes measures associated with time and frequency of mission execution and completion and overall friendly losses and enemy kills. There are a total of 12 measures. Seven measures are collected using automatic data

collection methods. Five measures are collected using manual data collection methods.

Information Acquisition and Communication

This category includes measures associated with the volume of report transmissions the commander's acquisition of information through visual resources, i.e., vision blocks and paper maps. There are a total five measures. All five measures are collected using manual data collection methods.

Tactical Assessment and Planning

This category includes measures associated with the quantity, accuracy, and timeliness of the unit's tactical situation assessment and successful execution of the tactical decisions. There are at total of 27 measures. All 27 measures are collected using manual data collection methods.

Operational Control of Unit

This category includes measures associated with unit dispersion and quantity of target engagements. There are a total of nine measures. Eight measures are collected using automatic data collection methods. One measure is collected using manual data collection methods.

Unit Positioning and Navigation

This category includes measures associated with maneuvering effectiveness, maneuvering efficiency,and crew navigation-related communications indirectly related to both effectiveness and efficiency. There are a total of 12 measures. Six measures are collected using automatic data collection methods. Six measures are collected using manual data collection methods.

Target Acquisition and Engagement

This category includes measures associated with acquiring, hitting, or killing enemy vehicles or with the risk of sustaining hits when exposed to the enemy during engagements. There are a total of seven measures. Six measures are collected using automatic data collection methods. One measure is collected using manual data collection methods.

Performance Measure Variability

The POSNAV, IVIS, and CVCC evaluation results demonstrate that the formulated performance measures are useful for discriminating between baseline and experimental systems. Measured performance of baseline system crews, platoons, and companies, in general, has been more variable relative to the

measured performance of their experimental system counterparts. In addition, certain measures have been shown to be more variable than others. Variable performance measures ranged across five of the six categories. Only the Target Acquisition and Engagement category had no particular instances of relatively variable performance measures.

Du Bois and Smith (1989) reported crew and platoon performance was widely variable in the baseline system condition. In the POSNAV evaluation, standard deviations ranged as high as 90% of the mean value for some measures. Specifically, crew performance was widely varied in accuracy measures associated with reporting checkpoint locations and own locations. Platoon performance was widely varied in dispersion measures, distance traveled measures, and accuracy measures for artillery fire location and own location reports. For the IVIS evaluation, crew performance was more varied in report accuracy and report time measures and platoon performance was more varied in report accuracy, report time, and dispersion measures.

An analysis of the coefficient of variation (COV), an indicator of a measure's variability relative to the mean, indicates several CVCC company-level measures were variable. If only measures with COVs above .50 are considered across offensive and defensive scenarios, there are 14 measures (ranging from .54 to 3.59) that can be identified. Baseline system company-level measures falling in this COV range include: number of tethered vehicle losses; ratio of manned vehicle losses to enemy targets killed; number of named reports; number of voice radio messages; number of reports to clarify FRAGOs and INTEL reports; time to plan and process FRAGOs; percent time manned platoon dispersion exceeded 200 meters; percent time manned platoon dispersion fell below 100 meters; percent time company dispersion exceeded 600 meters; percent rounds fired by company commanders and platoon leaders; company commander tank's average distance from company's center of mass; number of times manned vehicles out of sector; fuel used; and distance traveled.

What is important to understand about using these highly variable measures is the impact they have on designing reliable data collection into missions, exercises, and scenarios and the overall evaluation effort. Researchers may have to increase the number of opportunities for sampling the performance measures within a mission, exercise, or scenario which concomitantly increases the time to conduct the mission, exercise, or scenario. As an example, Du Bois (1989) estimated he would have to double the time needed, i.e., 4 to 8 hours, for a small unit exercise in order to obtain higher reliability estimates for his measures. Alternatively, researchers may elect to increase the sample size for the entire evaluation which would increase the overall length of time and costs needed for its completion. Although reliability of the performance measures may increase by using

either or both of these methods, a tradeoff has to be made between collecting more performance measure samples and staying within the practical constraints of conducting real-time evaluations in the CCTB.

How To Use This Catalog

The catalog of baseline system performance measures can be found immediately after this section. The appendices of this report contain a glossary of terms explaining the catalog of baseline performance measures (Appendix A) and the performance measure definitions organized according to the categories and numerical listing associated with the catalog (Appendix B).

Using the Catalog

In the catalog, the performance measures are organized according to six categories: mission performance, information acquisition and communication, tactical assessment and planning, operational control of unit, and target acquisition and engagement. Each category has a number associated with it, i.e., 1 through 6. Additionally, the performance measures are consistently organized within categories and across categories. Generally, time measures appear first, quantity (number or percentage) measures appear next, accuracy measures appear third, and the rest are arbitrarily designated within a category.

All category headings and subsequent performance measures are numerically coded. For example, the Mission Performance category has a number "1." appearing parallel and to the left. The performance measure "Time to execute road march" appears below the category heading with the number "1.1" appearing parallel and to the left. All the other performance measures follow the same organization.

The rest of the table contains columns of coded information related to each performance measure. To the right of the performance measures, the "Data Collection Method" column contains the codes indicating how the associated performance measure data was recorded. The next column to the right, the "Level" column, contains the coded echelon level at which data is collected. The last column on the right, the "Exp" column, contains the code representing the experiments the performance was extracted from.

Some confusion could result in interpreting the information across the "Level" and "Exp" columns in this table. For example, performance measure "1.4 Time to execute mission," did not contain the code PLT in the "Level" column even though CREW and CO are mentioned. This appears to be inconsistent but it is not. This performance measure was not collected at the platoon level in any of the cited experiments even though all three experiments

are represented by coded letters in the "Exp" column. This measure was only collected at the crew level in the POSNAV and IVIS experiments and at the CO level in the CVCC experiment. Platoon level mission time was captured in performance measure 1.2, "Time used per mission segment." The difference is that mission performance time was defined differently for PLT level than for CREW and CO levels. These performance measures are defined and associated in the manner and level that they were collected in the original experiment. However, this does not prevent any of the performance measures from being used at different levels (in future studies) than the manner in which they were collected.

Using the Glossary

In Appendix A, all the codes and definitions used within the catalog are explained. The "catalog heading" column lists the headings to be found in the catalog. The "code" column lists the acronym, words, or letter appearing as information in the "code" column of the catalog. The "explanation" column defines the codes listed in the "code" column for the catalog.

Using the Definitions

Appendix B contains the operational definitions of the performance measures listed in the catalog. The performance measure definitions appear in the same order as the table listings and are similarly numericaly organized.

The operational definitions are text descriptions of the information needed for understanding and replicating the measure. The following information is generally included in most of the definitions:

1. Initiating and terminal events for data capture (if applicable or available in the referenced reports).

2. The level at which the measure was collected, e.g., crew.

3. The circumstances for data capture, i.e., exercise, offensive or defensive combat mission, or phase of an offensive or defensive scenario.

4. The statistical summary utilized for the measure, e.g., average, sum, cumulative count, percent, etc.

Some measures contain more than one operational definition. Multiple definitions occurred under one performance measure due to differences in events, levels, circumstances, and/or statistical summary. For example, the performance measure "5.10 Fuel used" has three differing definitions based on differences

in the collection level, data capturing circumstances, and the statistical summary used.

CATALOG OF PERFORMANCE MEASURES

NO.	RERFORMANCE MEASURES	DATA COLLECTION METHOD	LEVEL	EXP
1.	**Mission Performance**			
1.1	Time to execute road march	PVD,LOG	CREW	P
1.2	Time used per mission segment	PVD,LOG	PLT	P,I
1.3	Time to execute fragmentary orders (FRAGOs)	PVD,LOG	CREW,PLT	P,I
1.4	Time to execute mission	PVD,LOG	CREW,CO	P,I,C
1.5	Number of mission segments completed	LOG	PLT	P,I
1.6	Number of FRAGOs executed	LOG	CREW,PLT	P,I
1.7	Number of missions completed	LOG	PLT,CO	P,C
1.8	Number of manned vehicle losses	ADC	CO	C
1.9	Number of tethered vehicle losses	ADC	CO	C
1.10	Percent enemy vehicles killed by manned vehicles	ADC	CO	C
1.11	Percent enemy vehicles killed by Blue Force	ADC	CO	C

NO.	PERFORMANCE MEASURES	DATA COLLECTION METHOD	LEVEL	EXP
1.12	Ratio of manned vehicle losses to enemy targets killed	ADC	CO	C
2. Information Acquisition and Communication				
2.1	Number of named reports (by report type)	LOG	CO	C
2.2	Number of voice radio messages (other than named reports)	LOG	CO	C
2.3	Number of requests to clarify FRAGOs and INTEL reports	LOG	CO	C
2.4	Percent time tank commanders (TCs) used vision blocks	LOG	CREW,PLT	P,I
2.5	Percent time TCs used paper map	LOG	CREW,PLT	P,I
3. Tactical Assessment and Planning				
3.1	Time to plan road march	LOG	CREW	P
3.2	Time to plan battle position	PVD,LOG	CREW	I
3.3	Time to plan FRAGOs	PVD,LOG	CREW,PLT	I
3.4	Time to plan and process FRAGOs	PVD,LOG	CO	C
3.5	Time to plan mission	LOG	CREW	I
3.6	Time to report own location	PVD,LOG	CREW	P,I

NO.	PERFORMANCE MEASURES	DATA COLLECTION METHOD	LEVEL	EXP
3.7	Time to report own location and control measures	PVD,LOG	PLT	I
3.8	Time to report indirect fire - SHELL report	PVD,LOG	CREW,PLT	P,I
3.9	Time to report enemy locations or battlefield engagements - SPOT report	PVD,LOG	CREW,PLT	P,I
3.10	Time to report battlefield activity - all Call for Fire (CFF) and SPOT reports	PVD,LOG	PLT	I
3.11	Time to reach target effect - initial CFF and adjustments	PVD,LOG	CREW	I
3.12	Time to occupy battle position	PVD,LOG	CREW	I
3.13	Timeliness of first CONTACT report	PVD,LOG	CO	C
3.14	Number of CONTACT reports sent	PVD,LOG	CREW,PLT	I
3.15	Number of SHELL reports sent	PVD,LOG	CREW,PLT	I
3.16	Number of SPOT reports sent	PVD,LOG	CREW	I
3.17	Number of battlefield activity reports sent - CFF and SPOT reports	PVD,LOG	PLT	I
3.18	Number of CFF reports sent	PVD,LOG	CO	C

NO.	PERFORMANCE MEASURES	DATA COLLECTION METHOD	LEVEL	EXP
3.19	Number of CFF adjustments sent - ADJUST FIRE reports	PVD,LOG	CREW	I
3.20	Number of indirect fire (CFF) tasks in which target effect is reached	LOG	CREW	I
3.21	Accuracy of reported own location	PVD,LOG	CREW,PLT	P,I
3.22	Accuracy of reported own location and control measure location	PVD,LOG	PLT	I
3.23	Accuracy of reported control measure and checkpoint locations	PVD,LOG	CREW	P,I
3.24	Accuracy of reported artillery fire locations - SHELL report	PVD,LOG	CREW,PLT	P,I
3.25	Accuracy of reported enemy locations - SPOT report	PVD,LOG	CREW,PLT	P,I
3.26	Accuracy of reported locations - initial CFF report	PVD,LOG	CREW	I
3.27	Accuracy of reported locations for all CFF and SPOT reports	PVD,LOG	PLT	I
3.28	Accuracy of reported enemy identification - CONTACT or SPOT reports	PVD,LOG	CREW	I

NO.	PERFORMANCE MEASURES	DATA COLLECTION METHOD	LEVEL	EXP
3.29	Accuracy of reported enemy direction - CONTACT report	PVD,LOG	CREW	I
3.30	Accuracy of reported number of enemy - SPOT report	PVD,LOG	CREW	I
3.31	Success in occupying battle position	PVD,LOG	CREW	I
3.32	Unit displacement range	PVD,LOG	CO	C
4. Operational Control of Unit				
4.1	Time platoon (PLT) dispersed per completed segment	PVD,LOG	PLT	P
4.2	Percent time within section dispersion exceeded 200 meters and 500 meters	ADC	PLT	I
4.3	Percent time between section dispersion exceeded 500 meters	ADC	PLT	I
4.4	Percent time manned PLT dispersion exceeded 200 meters	ADC	PLT	C
4.5	Percent time manned PLT dispersion fell below 100 meters	ADC	PLT	C
4.6	Percent time CO dispersion exceeded 600 meters	ADC	CO	C

NO.	PERFORMANCE MEASURES	DATA COLLECTION METHOD	LEVEL	EXP
4.7	Percent time CO dispersion fell below 300 meters	ADC	CO	C
4.8	Percent rounds fired by CO commander (CC) and PLT leaders (PLs)	ADC	CO	C
4.9	CC tank's average distance from CO's center of mass (COM)	ADC	CO	C
5. Unit Positioning and Navigation				
5.1	Time to successfully execute obstacle bypasses	PVD,LOG	CREW	I
5.2	Number of successful obstacle bypasses	LOG	CREW	I
5.3	Number of TC to driver communications	LOG	CREW,PLT	P
5.4	Number of driver to TC communications	LOG	CREW,PLT	P
5.5	Number of times manned vehicles out of sector	LOG	CO	C
5.6	Percent time moving velocity exceeded 40 KPH	ADC	CO	C
5.7	Percent time at halt	ADC	CREW,PLT,CO	P,C
5.8	Velocity (while moving)	ADC	CREW,PLT,CO	I,C

NO.	PERFORMANCE MEASURES	DATA COLLECTION METHOD	LEVEL	EXP
5.9	Velocity (overall)	ADC	CREW,PLT	P,I
5.10	Fuel used	ADC	CREW,PLT,CO	P,I,C
5.11	Distance traveled	ADC	CREW,PLT,CO	P,I,C
5.12	Successful bypass of NBC area	LOG	CREW	P
6. Target Acquisition and Engagement				
6.1	Number of hits taken by manned vehicles	ADC	CREW	C
6.2	Percent targets hit at ranges exceeding 2200 meters	ADC	CREW	C
6.3	Percent targets killed at ranges exceeding 2200 meters	ADC	CREW	C
6.4	Range of target engagements	ADC	CREW,PLT	I
6.5	Median target hit range	ADC	CREW	C
6.6	Median target kill range	ADC	CREW	C
6.7	Maximum lasing range	ADC	CREW	C

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APPENDIX A

GLOSSARY OF TERMS

Table Heading	Code	Explanation
DATA COLLECTION METHOD	ADC/ LOG/ PVD	Automatic data collection (ADC) implies automated sampling of data by Data Logger; LOG refers to manual collection of data recorded into logs by controllers, research assistants, and other data collectors; Plan View Display (PVD) implies manually flagging events for recording into Data Logger.
LEVEL	CREW PLT CO	Level represents the data point at which the performance measure is collected. CREW equals the whole tank, whole crew, crewmember, or TC performance; platoon (PLT) equals whole PLT, Section, platoon leader (PL), or aggregate of tanks, crews, or individual crewmembers performance; company (CO) equals the performance of whole CO, aggregate of specified vehicles or manned vehicles or CO commanders (CC) and PLT leaders (PL), the CC, or the CC, any PL, or any manned vehicle.
EXP	P I C	Experiment (EXP) is the research represented in this report from which performance measures were culled. P represents POSNAV (Du Bois & Smith, 1989); I represents IVIS (Du Bois & Smith, 1991); C represents CVCC (Leibrecht et al, 1992).

APPENDIX B

OPERATIONAL DEFINITIONS

1. Mission Performance

1.1 Time to execute road march

Average time in minutes for a crew to execute all road marches. Excludes planning time, breaks, and simulator interruptions.

1.2 Time used per mission segment

Average time in minutes the PLT used to execute and complete mission segments per offensive or defensive combat mission or for all offensive missions. The average is derived by summing all the completed segment times and dividing by the number of segments executed. (Segments not completed are not used in calculating the average.) An example of a segment would be the PLT's departure from a release point until arrival at a checkpoint.

1.3 Time to execute fragmentary orders (FRAGOs)

Average time in minutes for the PLT to successfully execute the first mission FRAGO over all offensive missions.

or

Average time in minutes for FRAGOs to be executed by the crew in an exercise or by the PLT in a particular combat mission, i.e., offensive or defensive mission.

1.4 Time to execute mission

Elapsed time in minutes for a crew to execute the exercise. Excludes crew planning time and exercise breaks.

or

Elapsed time in minutes from the company's (CO's) start of mission execution (i.e., following radio command "REDCON 1") to the completion of the last scripted event in the phase. The manned vehicle with the longest time to complete the phase is selected to represent the CO's mission time. Excludes planning and in-simulator vehicle preparation preceding the start of the initial mission in a scenario. One measure collected per CO per phase in offensive and defensive scenarios.

1.5 Number of mission segments completed

Of the total number of possible mission segments to be executed, the number of mission segments successfully completed by the PLT in all offensive missions or in a particular combat mission, i.e., offensive or defensive mission.

1.6 Number of FRAGOs executed

Average number of FRAGOs successfully executed by a PLT in all offensive missions.

or

The number of FRAGOs compleated by the crew in a an exercise or by the PLT in a particular combat mission, i.e., offensive or defensive mission.

1.7 Number of missions completed

Out of the two offensive missions administered, the number of missions completed by the PLT during a specified time limit, i.e., two and a half hours.

or

Of phases scripted per scenario, the number completed by the CO in each scenario. One measure collected per CO per offensive or defensive scenario.

1.8 **Number of manned vehicle losses**

Sum of the cumulative number of times each manned vehicle sustained hits which the computer classified as notional kills (including fratricide kills). Multiple kills may be sustained by each manned vehicle. One set of measures collected per CO per phase in offensive and defensive scenarios.

1.9 **Number of tethered vehicle losses**

Cumulative number of times the combined tethered vehicles sustained direct fire hits which the computer classified as "destroyed." (Tethered vehicles refers to SAFOR vehicles linked to manned simualtors for reasons of controling their movements and tactical formations.) Classification of "destroyed" includes fratricide kills but excludes mobility kills. One measure collected per CO per phase in offensive and defensive scenarios.

1.10 **Percent enemy vehicles killed by manned vehicles**

Of the total number of enemy vehicles and gunnery targets killed by manned and semi-automated tethered vehicles' direct fire, the proportion accounted for by the manned vehicles combined. One measure collected per CO per phase in offensive and defensive scenarios.

1.11 **Percent enemy vehicles killed by Blue Force**

Of the total number of enemy vehicles participating in the battle, the proportion killed by the entire friendly force (manned and semi-automated tethered vehicles). Kills include catastrophic kills and firepower kills but exclude mobility kills. One measure collected per CO per phase in offensive and defensive scenarios.

1.12 Ratio of manned vehicle losses to enemy targets killed

The total number of Blue Force manned vehicles killed by all Red Force vehicles compared to the total number of Red Force vehicles and gunnery targets killed by Blue Force manned vehicles. One measure collected per CO per phase in offensive and defensive scenarios.

2. Information Acquisition and Communication

2.1 Number of named reports (by report type)

Volume of formatted reports transmitted by radio and sorted by report type (as defined by accepted Armor practice). Named reports are counted by vehicle by type without duplication. Named reports include: CONTACT, SPOT, CALL FOR FIRE, ADJUST FIRE, NBC, SITUATION, ROUTE, SHELL, and AMMO. One set of measures collected for company commander (CC) and PLT leaders (PLs) per phase in offensive and defensive scenarios.

2.2 Number of voice radio messages (other than named reports)

Volume of unformatted messages transmitted by radio sorted by report type. "Other" (non-named) reports include: movement; location; navigation; identification of any vehicle, landmark, etc.; equipment related information; miscellaneous information regarding friendly units; miscellaneous information regarding enemy units; and all other messages. Reports not to be counted include named reports, REDCON 1, requests for clarification, clarifications, cease movement for breaks, equipment problems, and repeats. One measure collected for CC and PLs per phase in offensive and defensive scenarios.

2.3 Number of requests to clarify FRAGOs and INTEL reports

Total number of times the CC and PLs request clarification of a FRAGO or INTEL report. Clarification requests are summed across the CC and the three PLs. One measure collected per CO per phase in offensive and defensive scenarios.

2.4 Percent time tank commanders (TCs) used vision blocks

Mean percent of time the TCs used the SIMNET-D M1's vision blocks during all road marches, an exercise, all offensive missions, or per offensive or defensive combat mission. This measure is the combination of the TC's estimation and the research assistant's estimation of relative time spent using the vision blocks.

2.5 Percent time TCs used paper map

Mean percent of time the TCs used the SIMNET-D paper map during all road marches, an exercise, all offensive missions, or per

offensive or defensive combat mission. This measure is the combination of the TC's estimation and the research assistant's estimation of relative time spent using the paper map.

3. Tactical Assessment and Planning

3.1 Time to plan road march

Average time in minutes for the crew to plan all road marches.

3.2 Time to plan battle position

Time in minutes the TC used to plan the occupation of a battle position. Measured from the end of the FRAGO transmission until the TC reports ready status and begins execution of the task.

3.3 Time to plan FRAGOs

Average time in minutes used for FRAGO planning by the TC in an exercise or by the PL per offensive or defensive combat mission. Measured from end of FRAGO radio transmission until TC or PL reports ready status and begins FRAGO execution.

3.4 Time to plan and process FRAGOs

Elapsed time in minutes from the start of transmission of the FRAGO by Battalion staff to the subsequent transmission of the FRAGO by the CC. This measure reflects the CC's planning and processing of received FRAGOs. One measure collected per CC per phase in offensive and defensive scenarios.

3.5 Time to plan mission

Elapsed time in minutes from the finish of the operation order briefing until the TC reports ready to execute the exercise.

3.6 Time to report own location

Average elapsed time in seconds from the controller prompt for a location report until the TC transmits the report. This value is averaged across the number of location report prompts during all road marches or across all prompts in an exercise.

3.7 Time to report own location and control measures

Average elapsed time in seconds from the controller prompt for a location report or arrival at a checkpoint until the PL transmits a report. This value is averaged across the number of location report prompts plus the number of reported checkpoints per offensive or defensive combat mission.

3.8 Time to report indirect fire - SHELL report

Average elapsed time in seconds from shell impact until the TC or PL transmits a SHELL report. This value is averaged across the number of indirect fire barrages during a tank exercise or across all PLT offensive missions.

3.9 Time to report enemy locations or battlefield engagements - SPOT report

Average elapsed time in seconds from the end of battlefield engagements until the TC transmits a report. This value is averaged across the number of battlefield engagements in an exercise.

or

Mean time in minutes for the PL to report enemy locations in all offensive missions.

3.10 Time to report battlefield activity - all Call for Fire (CFF) and SPOT reports

Mean time in seconds for the PL to report all CFF and SPOT reports throughout an offensive or defensive combat mission. This measure is averaged across the number of CFF tasks and battlefield engagements in a particular combat mission.

3.11 Time to reach target effect - initial CFF and adjustments

Mean elapsed time in minutes from the time the TC issues a CFF report (target acquisition) until target effect is reached or five more adjustments are sent without target effect. Target effect is reached when artillery is directed within 200 meters of the target location. This measure is averaged across the number of CFF tasks in an exercise.

3.12 Time to occupy battle position

Elapsed time in minutes for the crew to occupy the assigned battle position. Measured from the time the tank moves out until the TC reports securing the battle position.

3.13 Timeliness of first CONTACT report

Elapsed time in minutes from the first reported sighting of the enemy, the first transmission of a CONTACT report by a PL or CC until the start of the battlefield engagement, i.e., the first friendly or enemy shot fired. The value may be negative if firing started before the CONTACT report. One measure collected per CO per phase in offensive and defensive scenarios.

3.14 Number of CONTACT reports sent

Cumulative number of CONTACT reports sent by the TC during an exercise or by the PL during an offensive or defensive combat mission.

3.15 Number of SHELL reports sent

Cumulative number of SHELL reports transmitted by the TC during an exercise or by the PL during an offensive or defensive combat mission.

3.16 Number of SPOT reports sent

Cumulative number of SPOT reports transmitted by the TC during an exercise.

3.17 Number of battlefield activity reports sent - CFF and SPOT reports

Total number of both CFF and SPOT reports transmitted by the PL during an offensive or defensive combat mission.

3.18 Number of CFF reports sent

Cumulative number of artillery fire requests transmitted by the CC. The value reflects information processing by the entire CO. One measure collected per CO per phase in offensive and defensive scenarios.

3.19 Number of CFF adjustments sent - ADJUST FIRE reports

Mean number of CFF adjustments sent by the TC before reaching target effect during an exercise. Target effect is reached when artillery is directed within 200 meters of target location. Maximum adjustments limited to initial CFF plus five adjustments. If no target effect is reached or the CFF results in the crew's destruction, the CFF task is ended.

3.20 Number of indirect fire (CFF) tasks in which target effect is reached

Total number of CFF tasks for which the target effect is reached during an exercise. Target effect is reached when the TC directs artillery within 200 meters of target location and accomplishes the fire mission within five adjustments after the initial CFF report.

3.21 Accuracy of reported own location

Mean deviation in meters between actual grid locations of the tank or PLT and grid locations reported by the TC during all

marches or an exercise or by the PL during all offensive missions, respectively. Deviations are averaged across the number of prompted location reports in all marches or per exercise or all offensive missions.

3.22 Accuracy of reported own location and control measure location

Mean deviation in meters between the actual grid locations of the PLT and control measures and the grid locations reported by the PL. Deviations are averaged across the number of prompted location reports plus the number of reported checkpoints in a particular combat mission, i.e. offensive or defensive mission.

3.23 Accuracy of reported control measure and checkpoint locations

Mean deviation in meters between the tank's actual grid locations and the grid locations reported by the TC upon arrival at checkpoints. Deviations are averaged across the number of reported control measures and checkpoints in all marches or an exercise.

3.24 Accuracy of reported artillery fire locations - SHELL reports

Mean deviation in meters between the actual grid locations of artillery or mortar shell impacts and the TC's or PL's reported grid locations. Deviations are averaged across the number of indirect fire barrages during a tank exercise, all PLT offensive missions, or a particular PLT combat mission, i.e., offensive or defensive mission.

3.25 Accuracy of reported enemy locations - SPOT reports

Mean deviation in meters between actual grid locations of enemy vehicles or battlefield engagements and grid locations reported by the TC or PL. Deviations are averaged across the number of enemy vehicle locations in all PLT offensive missions or the number of battlefield engagements in a tank exercise.

3.26 Accuracy of reported locations - initial CFF report

For the initial CFF report in an exercise, the deviation in meters between the actual enemy target grid location and grid location reported by the TC.

3.27 Accuracy of reported locations for all CFF and SPOT reports

Mean deviation in meters between the actual grid locations and the PL's reported grid locations in all CFF and SPOT reports during a particular mission, i.e., offensive or defensive

mission. Deviations are averaged across the number of indirect fire missions (CFF tasks) and battlefield engagements in a particular combat mission.

3.28 Accuracy of reported enemy identification - CONTACT or SPOT reports

For CONTACT report accuracy it is the total number of TC CONTACT reports sent with the correct identification of enemy vehicles (e.g., tanks, PCs) sighted during an exercise.

or

For SPOT report accuracy it is the total number of TC SPOT reports sent with the correct identification of enemy vehicles engaged during an exercise.

3.29 Accuracy of reported enemy direction - CONTACT report

The total number of TC CONTACT reports sent with the correct cardinal direction of the enemy vehicles (e.g., east, west) during an exercise.

3.30 Accuracy of reported number of enemy - SPOT report

The total number of TC SPOT reports sent with the correct number of enemy engaged during an exercise.

3.31 Success in occupying battle position

A dichotomous measure indicating success or failure in occupying an assigned battle position. The tank must be within 500 meters of the grid coordinates of the assigned battle position and must orient the main gun within assigned sectors.

3.32 Unit displacement range

Direct straight line distance (in meters) between the closest friendly manned vehicle and enemy vehicle at the time the CC orders the first element to displace or disengage. Applies to a delay mission (defensive) only. One measure collected per CO per defensive scenario.

4. Operational Control of Unit

4.1 Time PLT dispersed per completed segment

Out of all PLT offensive missions, the mean number of seconds per completed segment at least one tank is dispersed from the PL's tank by more than 1000 meters or 600 meters.

4.2 Percent time within section dispersion exceeded 200 and 500 meters

Of the total PLT's combat mission time (i.e., offensive or defensive mission), the proportion of time that either PLT section has its tanks separated by more than 200 meters.

and

Of the total PLT's combat mission time, the proportion of time that either PLT section has its tanks separated by more than 500 meters.

4.3 Percent time between section dispersion exceeded 500 meters

Of the total PLT's combat mission time (i.e., offensive or defensive mission), the proportion of time that the two sections are separated by more than 500 meters. Measure taken between the two section tanks with the greatest distance apart.

4.4 Percent time manned PLT dispersion exceeded 200 meters

Of the total number of samples captured over the phase (i.e., every 30 seconds), the number of times any manned PLT vehicle has a linear distance from the PLT's geometric center of mass (COM) greater than the acceptable maximum defined by Army doctrine, i.e., 200 meters. The manned PLT's geometric COM is defined relative to the location of all four of the PLT's vehicles. One measure collected per CO per phase in offensive scenarios only.

4.5 Percent time manned PLT dispersion fell below 100 meters

Of the total number of samples captured over the phase (i.e., every 30 seconds), the number of times any manned PLT vehicles has a linear distance below the acceptable minimum defined by Army doctrine, i.e., less than 100 meters from the manned PLT's geometric COM. The manned PLT's geometric COM is defined relative to the location of all four of the PLT's vehicles. One measure collected per CO per phase in offensive scenarios only.

4.6 Percent time CO dispersion exceeded 600 meters

Of the total number of samples captured over a phase (i.e., every 30 seconds), the number of times any Blue Force CO manned vehicle has a linear distance greater than 600 meters from the CO's geometric COM. CO geometric COM is defined relative to the manned (second) PLT's COM and first and third PLTs' locations. (Unlike the second PLT, the first and third PLTs consists of one manned vehicle (PL) and three semi-automated tethered vehicles.) One measure collected per CO per phase on offensive scenarios only.

4.7 Percent time CO dispersion fell below 300 meters

Of the total number of samples captured over the phase (i.e., every 30 seconds), the number of times any Blue Force CO manned vehicle has a linear distance from the CO's geometric COM below the acceptable minimum defined by Army doctrine, i.e., less than 300 meters. CO geometric COM is defined relative to the manned (second) PLT's COM and first and third PLTs' locations. (Unlike the second PLT, the first and third PLTs consists of one manned vehicle (PL) and three semi-automated tethered vehicles.) One measure collected per CO per phase in offensive scenarios only.

4.8 Percent rounds fired by CO commander (CC) and PLT leaders (PLs)

Of the total main gun rounds (i.e., heat and sabot) expended by all manned vehicles, the proportion which is fired by each CC and PL's vehicles. One set of measures collected per CC and PLs' vehicles per phase in offensive and defensive scenarios. phases.

4.9 CC tank's average distance from CO's center of mass

Mean linear distance (in meters) of the CC's vehicle relative to the CO's geometric COM. CO geometric COM is defined relative to the manned (second) PLT's COM and first and third PLTs' locations. (Unlike the second PLT, the first and third PLTs consists of one manned vehicle (PL) and three semi-automated tethered vehicles.) The value is computed every 30 seconds during a phase. One set of measures collected per CC per phase in offensive scenarios only.

5. Unit Positioning and Navigation

5.1 Time to successfully execute obstacle bypasses

Of the number of obstacle bypass tasks in an exercise, the total time in minutes it takes a tank crew to perform successful obstacle bypasses. A successful bypass is one in which the tank does not enter a minefield or an NBC contaminated area.

5.2 Number of successful obstacle bypasses

Of the number of obstacle bypass tasks in an exercise, the number of obstacle bypasses successfully completed by the tank crew.

5.3 Number of TC to driver communications

Mean number of TC to driver navigation-related communications for a tank during all marches or for all crews in a PLT per completed mission segment for all PLT offensive missions.

5.4 Number of driver to TC communications

Mean number of driver to TC navigation-related communications for a tank during all marches or for all crews in a PLT per completed segment for all PLT offensive missions.

5.5 Number of times manned vehicles out of sector

Number of instances a manned vehicle travelled identifiably outside established boundaries of the CO's assigned sector. Out of sector judgements are made relative to overlay graphics on the PVD screen. One set of measures collected per CO per phase in offensive and defensive scenarios.

5.6 Percent time moving velocity exceeded 40 KPH

Out of the total number of samples captured over a phase, the percent of time each manned vehicle's velocity is faster than 40 KPH. The percentage is based on samples captured every 30 seconds and excludes periods the vehicles are at halt. One set of measures collected from vehicles per phase in offensive and defensive scenarios.

5.7 Percent time at halt

Mean percent of time the tank or PLT was at a halt during all marches or all offensive missions, respectively.

or

Of the total number of samples captured over a phase, the percent of time each manned vehicle's velocity was zero (stopped). The percentage is based on samples captured every 30 seconds and excludes periods the vehicles are moving. One set of measures collected from CO vehicles per phase in offensive scenarios only.

5.8 Velocity (while moving)

Mean velocity in kilometers per hour (KPH) measured only while the tank is moving during an exercise or PLT is moving during a particular combat mission, i.e., offensive or defensive mission. Excludes periods when the tank or PLT is at halt.

or

Mean velocity in kilometers per hour (KPH) per manned vehicle (when moving) during mission execution. The average is based on samples captured every 30 seconds and excludes periods when the vehicles are at halt. One set of measures collected for manned vehicles per phase in offensive and defensive scenarios.

5.9 Velocity (overall)

Mean tank velocity in kilometers per hour (KPH) over the duration of all road marches or an exercise or mean PLT velocity in KPH

over the duration of a particular combat mission, i.e., offensive or defensive mission.

5.10 Fuel used

Mean gallons of fuel used by the tank during all road marches or during an exercise.

or

Mean gallons of fuel used by the PLT's tanks in executing the first mission FRAGO averaged across all offensive missions or in all successfully completed segments in a particular combat mission, i.e., offensive or defensive mission.

or

Total gallons of fuel consumed per manned vehicle from the start to the end of the phase. One set of measures collected from CO manned vehicles per phase in offensive and defensive scenarios.

5.11 Distance travelled

Mean distance the tank travelled in kilometers to execute all marches or to complete an exercise.

or

Mean distance the PLT travelled in kilometers per successfully executed event in all offensive missions, to execute the first mission FRAGO in all offensive missions, or per mission segment completed in a particular combat mission, i.e., offensive or defensive mission.

or

Total meters driven from the start to the end of the mission. The value is derived from the change in manned vehicle odometer readings. One set of measures collected from all CO manned vehicles per phase in offensive or defensive scenarios.

5.12 Successful bypass of NBC area

A dichotomous measure indicating a crew's successful or unsuccessful bypass of an NBC area. An average of the failures and successes, scored as 0 and 1, respectively, is computed across all road marches.

6. Target Acquisition and Engagement

6.1 Number of hits taken by manned vehicles

Cumulative number of direct fire hits sustained by each manned vehicle. Excludes fratricide hits. Multiple hits may be sustained by each manned vehicle. One set of measures collected per manned vehicle per phase in offensive and defensive scenarios.

6.2 Percent targets hit at ranges exceeding 2200 meters

Of the total number of enemy vehicles fired upon and hit by each manned vehicle, the proportion occurring beyond the distance of 2000 meters. One set of measures collected per manned vehicle per phase in offensive and defensive scenarios.

6.3 Percent targets killed at ranges exceeding 2200 meters

Of the total number of enemy vehicles fired upon and killed by each manned vehicle, the proportion occurring beyond the distance of 2000 meters. One set of measures collected per manned vehicle per phase in offensive and defensive scenarios.

6.4 Range of target engagements

Mean range in meters of all target engagements by the tank or PLT during an exercise or particular combat mission, i.e., offensive or defensive mission.

6.5 Median target hit range

Median distance in meters that enemy targets were hit by each manned vehicle. One set of measures collected per manned vehicle per phase in offensive and defensive scenarios.

6.6 Median target kill range

Median distance in meters that enemy targets were killed by each manned vehicle. One set of measures collected per manned vehicle per phase in offensive and defensive scenarios.

6.7 Maximum lasing range

Maximum distance in meters from each manned vehicle to a potential target as determined by the TC's or gunner's use of the laser range finder (LRF). Indeterminate LRF readings are excluded from collection. One set of measures collected per manned vehicle per phase in offensive and defensive scenarios.